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What is the role of cyanide in mining?

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Cyanide is a naturally occurring chemical that is found in low concentrations throughout nature including in fruits, nuts, plants, and insects. It has been used by the mining industry to separate gold and silver particles from ore for over 120 years. With proper management, cyanide can be used safely and without harming the environment despite its toxicity.

Background information on cyanide

Cyanide is the general term for chemicals which contain a cyano group (triple-bonded carbon and nitrogen with the chemical formula CN) that occur naturally or are human-made in various forms. Low concentrations of cyanide are present in the everyday environment including as a stabilizer in table salt, in over 1000 plants including cassava and bamboo shoots, and in the pits of stone fruits like plums and apricots. [1, 2] In fact, the greatest source of cyanide exposure for people and free-ranging animals comes from eating food plants and crops that contain cyanide. [3]

Cyanide is also a useful industrial chemical; over one million tonnes of it are used annually in electroplating, metal processing, the production of organic chemicals and plastics, and in photographic applications. [2] The mining industry has used cyanide to process ore for more than 120 years, and uses less than 20% of the global production of industrial cyanide. [2, 4]

Role of cyanide in ore processing

Cyanide, in the form of a very dilute sodium cyanide solution, is used to dissolve and separate gold from ore. [3] The process used to extract gold using cyanide was developed in Scotland in 1887, and was first used in large scale commercial mining by the New Zealand Crown Mines Company at Karangahake in 1889. [3, 4] Cyanide leaching is considered to be a much safer alternative to extraction with **liquid mercury**, which was previously the main method of removing gold from ore. [5] Cyanide leaching has been the dominant gold extraction technology since the 1970s, although **small-scale and artisanal miners** continue to use mercury in some areas of the world. [3] In Canada, more than 90% of mined gold is extracted from ore using cyanide. [3]

The concentration of cyanide used in this process is normally in the range of 0.01% and 0.05% sodium cyanide (100 to 500 parts per million). [2] As part of their best practices, mines use as little cyanide as possible for environmental, safety, and economic reasons. [2] Cyanide leaching is usually done along with a physical process like milling, crushing, or gravity separation. The pH of the resulting slurry is raised by adding lime or another alkali to ensure that cyanide ions do not change into toxic cyanide gas (HCN). [6] The gold is then further concentrated and reduced, before being smelted into gold bullion. Click [here](#) to see a demonstration of the gold excavation and refinement process.

Cyanide toxicity and management

Cyanide is toxic in large doses and is strictly regulated in most jurisdictions worldwide to protect people, animals, and the aquatic environment. Cyanide prevents the body from taking up oxygen, resulting in suffocation, which may be fatal to humans and animals without prompt first aid treatment. [7] However, people and animals can rapidly detoxify non-lethal amounts of cyanide without negative effects, and repeated small doses can be tolerated by many species. [3] Some long-term health effects have been observed in people who have a diet high in cyanide-containing plants such as cassava, and include goiter and depressed thyroid function. [8]

In fact, "[d]espite its high human toxicity, there have been no documented accidental human deaths due to cyanide poisoning in the Australian and North American mining industries over the past 100 years which indicates that the hazard of cyanide to humans has been controlled by minimizing the risk of its handling and of industrial exposure." [6, p.4] Even in areas where cyanide is used extensively by **artisanal miners** with limited waste containment and safety practices, "human fatalities are relatively minimal particularly when compared with mercury or other hazards" [9, pp.109-110].

In high concentrations, cyanide is toxic to aquatic life, especially fish which are one thousand times more sensitive to cyanide than humans. [10] Because the greatest environmental threat from cyanide to aquatic life is from intentional or unintentional discharges into surface waters, **water monitoring** and **water management** on mine sites is very important. [11] Regulations frequently limit the amount of cyanide which may be discharged into the environment, and there are a number of **water treatment technologies**

Mining and the Environment

While mining has historically affected its surrounding environment, advances in technology and changes in management techniques mean that many negative impacts are now avoidable. Increasingly, mining companies are making efforts to reduce the environmental impact of mining and minimize the footprint of their activities throughout the mining cycle, including working to restore ecosystems post-mining.

This page will explore the issues surrounding mining and the environment and answer common questions.

Related Questions

[Does mining use mercury?](#)[What are the water quality concerns at metal mines?](#)

Video

On Bacteria, June 4, 2010 by
wildricegrains

[Link to page and download](#)

[Ozone provides cyanide destruction, uploaded by MiningWeekly, Sept. 10, 2010](#)

[The Process of Excavating and Refining Gold, uploaded by Triwood1973, Sept. 15, 2007](#)

Related Resources

International Cyanide
Management Institute.
[Cyanide Facts](#)

International Council on

available to remove cyanide from mine water. [2]

Birds and other wildlife are also potentially at risk from cyanide poisoning if they are using tailings ponds for drinking or swimming. [12] In order to prevent wildlife fatalities, cyanide levels in tailings ponds can be reduced to safe levels by minimizing the amount of cyanide used, removing cyanide in waste streams and recycling it, and by using chemical or biological reactions to convert the cyanide into less toxic chemicals. [13] A standard of 50 mg/L weak acid dissociable (WAD) cyanide is widely accepted to be a safe level for water accessible to wildlife, and has essentially eliminated the number of migratory bird deaths from this cause. [6, 11] Only a few hundred birds are killed by cyanide each year. [11] Deterrents like fencing, polyethylene balls, and netting are also used to keep birds out of water bodies on mine sites. [3]

Cyanides do not cause cancer, and do not build up or “biomagnify” in the food chain. [12] They do not persist in the environment, and are quickly broken down into less toxic chemicals by sunlight and air. [2]

Accidental Spills

Where cyanide has been accidentally released into surface waters, it has been investigated and changes have been made in the industry to prevent such releases happening again. One such change is the adoption of the [International Cyanide Management Code](#). This code was developed following several cyanide spills, in particular the Baia Mare spill in Romania in 2000. In the Baia Mare case, a dam failure that spilled cyanide into nearby waters resulted in widespread contamination, fish deaths, and economic harm—but no human deaths.

In such spills, the cyanide is rapidly destroyed through natural processes, such as evaporation, and the effects on aquatic life—while significant—are not long-term. [3] In the Baia Mare spill, the cyanide concentration decreased rapidly with increasing distance from the spill. After the contaminated water had passed, aquatic micro-organisms and plankton recovered within a few days. [10]

In Japan, an earthquake in 1980 resulted in a large amount of cyanide entering a stream from a gold mine. While the spill killed all life in the stream, cyanide was detectable for only three days after the spill; within 1 month flora began to regrow on above-water stones, and within 6-7 months the populations of fish, algae, and invertebrates had recovered. [3, p.29] Cyanide was also not detectable in water and sediments in Yellowknife Bay in the Northwest Territories from 1974 to 1976, despite a continuous input of cyanide-containing effluents from a gold mining operation (a practice that would not be permitted today). [3]

Legal framework for mines using cyanide

Many jurisdictions, including Canada and Australia, recommend that mines that use cyanide do so in a manner consistent with the International Cyanide Management Code, which involves minimizing the amount of cyanide used; designing measures to protect surface and groundwater; designing and operating systems that reduce cyanide levels in effluent; and preventing spills.

In Canada, cyanide is considered to be a hazardous substance, and provincial and federal legislation requires it to be transported, handled, and disposed of by fully trained personnel in certified storage containers. [12] Its disposal and discharge into the environment at mine sites is regulated provincially through the use of permits and licences. [12] In addition, the cyanide concentration of [effluent](#) leaving a metal mining operation must be below the maximum allowable concentration of 1.0 mg/L prescribed by the [Metal Mining Effluent Regulations](#) under the federal *Fisheries Act*. Cyanide in effluent is measured through [water sampling](#) and in 2010 metal mines achieved 100% compliance for cyanide. [14]

Alternative technologies to cyanide

Although cyanide can be safely used, the mining industry continues to research alternatives to cyanide and improve the techniques for managing the cyanide it does use. In some cases it may be possible to concentrate gold using gravity separation. However, this is not economical or feasible when the other ore components are of similar density or when the concentration of gold is low. [6]

Alternative extraction chemicals have also been studied, but they can be equally or more damaging to the environment than cyanide [6, 11]. Risk-based assessment by the US Environmental Protection Agency and Purdue University concluded that a cyanide-lime system was the safest chemical extraction method for recovering gold taking into account risk to the environment and workers [11].

Mining industry innovations have also included new cyanide-destruction technologies and management strategies to reduce cyanide concentrations, toxicity, and potential impacts. [2]

ⁱAccording to Mudder, T. et. al.(2006) an extensive literature search and review of fatalities in the mining industry estimated 6-10 work-related fatalities (not all confirmed) at mining operations and 1-2 fatalities within the civilian population attributed to cyanide exposure during the 20th century. By comparison, the World Health Organization estimates that tobacco caused 100 million deaths in the 20th century, and each year approximately 420,000 people die from falls, 1.3 million people die as a result of road traffic crashes, and 2.5 million people die from the harmful use of alcohol.

ⁱⁱAlternative methods to recover gold from ore include bromine/bromide/sulfuric acid, hypochlorite/chloride, ammonium thiosulfate/ammonia/copper, and thiourea/ferric sulfate/sulfuric acid.

Metals and the Environment. [The Management of Cyanide in Gold Extraction](#)

Laberge Environmental Services (2001). [Cyanide –The Facts](#)

Case Study: International Cyanide Management Code

The "International Cyanide Management Code for the Manufacture, Transport, and Use of Cyanide in the Production of Gold" (Code) was developed to provide comprehensive guidance on best practices for the use and management of cyanide at gold mines around the world. It was developed with input from a diverse range of groups including the United Nations, the World Bank, the Organisation for Economic Co-operation and Development (OECD), governments, environmental advocacy groups, mining companies and industry associations, and technical consultants. [6]

The Code is voluntary for the gold mining industry and focuses on the safe management of cyanide that is produced, transported, and used for processing gold. [15] The Code is intended to complement existing regulations, although the requirements extend beyond those of most governments and regulatory agencies. [6, 15]

There are two key elements to the Code. First, signatories must commit to defined principles and standards to manage cyanide responsibly. These principles cover cyanide production, transportation, handling and storage, operations, decommissioning, worker safety, emergency response, worker and emergency response personnel training, and public consultation and disclosure. [15] Within each principle key standards must be met. For example, as part of the "operations" principle, companies must commit to implementing monitoring programs to evaluate the effects of cyanide use on wildlife and surface and ground water quality. [15] In areas where mining companies don't have direct control, such as in the transportation and handling of cyanide, they must ensure that the other parties involved in these activities also commit to and comply with the Code. [15]

A second key element of the Code is that operations are subject to an independent third-party verification process. [15] It was the first voluntary industry Code of Practice that required independent third-party professional audits to demonstrate compliance. [6] **Signatory companies** and summaries of audit reports are published online to add to the transparency of the process. As of June 2012, there are 117 signatories to the Code comprising 36 gold mining companies, 13 cyanide producers, and 68 cyanide transporters.

The International Cyanide Management Institute estimates that half of the world's gold production is now being produced by signatory mining companies.[16] While most large producers have signed and adopted the Code, a key challenge remains in getting smaller producers to endorse it. [6]

Although it is too soon to fully evaluate the impacts of the Code, there are early indications that it is improving the management of cyanide use worldwide. The provisions of the code, especially concerning water management (i.e., the need to consider ranges of precipitation and melt, monitoring techniques, pumping capacity for excess water), would likely have prevented the Baia Mare spill had they been in place. [17] The number and severity of cyanide-related incidents appears to have declined since Baia Mare, although it is not clear if this is due to the Code itself or whether it coincides with increased awareness and improved management overall within the industry. [11, 16]

References

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